
Space Weather Technical Forecast

Issued on Tuesday, 10 October 2023 at 13:29 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: Chance of isolated M-class flares throughout but Likely Days 1-3 (10-12 Oct). Chance G1/Minor Geomagnetic Storm intervals Days 1-3 from coronal hole fast winds and CME arrival (11-12 Oct). Slight chance of R1/Minor Solar Radiation Storm throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate with an isolated M-flare and frequent C-flares, peak of M1.6 at 10/0209 UTC from AR3451 in the northwest. There are currently eleven sunspot regions on the visible disc. AR3451 in the northwest is the largest and most magnetically complex, with persistence of a weak delta spot on its trailing portion. AR3460 towards the centre disc although smaller, is also a complex region, with a moderately strong delta spot present on this regions trailing spot. The other regions are all smaller and simpler, although a couple have shown some slight growth and development, with AR3462 recently reclassified as Dso/Beta following penumbra development. No Earth-directed CMEs have been detected. A CME observable on the latest coronagraph imagery (from around 10/1030 UTC) is yet to be analysed, however, it does not appear to have emanated from a feature on the visible disc.

Solar Wind / Geomagnetic Activity: Solar winds as observed at L1 by ACE/DSCOVR have persisted at generally slow-ambient conditions, with no definitive indication of CH57/- fast winds. The solar wind speed has shown a slight downwards trend from 350kms to around 310km/s, and is now weakly fluctuating. Density was initially below average, increasing to average 09/1800 UTC-09/2335 UTC with a peak of 9ppcc. Total interplanetary magnetic field (IMF) strength, Bt, was weak throughout. The north-south component, Bt, was largely negative, but since 09/1800 UTC has been predominantly positive (northward), ranging -6 nT to +5 nT. Phi angle was generally positive (away from the Sun) with a number of periods of negative (towards the Sun), most notably between 09/2100 UTC and 10/0020 UTC. Geomagnetic activity has been Quiet to Unsettled (Kp 1-3).

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux was at background levels. GOES16 high energy (greater than 2MeV) electron flux was Background to Moderate, peaking 276 pfu at 09/1620 UTC. Associated 24-hour fluence was below the Active (1e8 integrated pfu) threshold. The observation at 10/0000 UTC was 3.40e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate activity is expected with isolated M-flares likely from AR3451 or AR3460 Days 1-3 (10-12 Oct). The risk is then expected to lower as AR3451 departs the disc, however, emerging or returning regions during the period maintains the chance of M-flares throughout. There is a slight chance of very isolated X-flare from either AR3451 or AR3460.

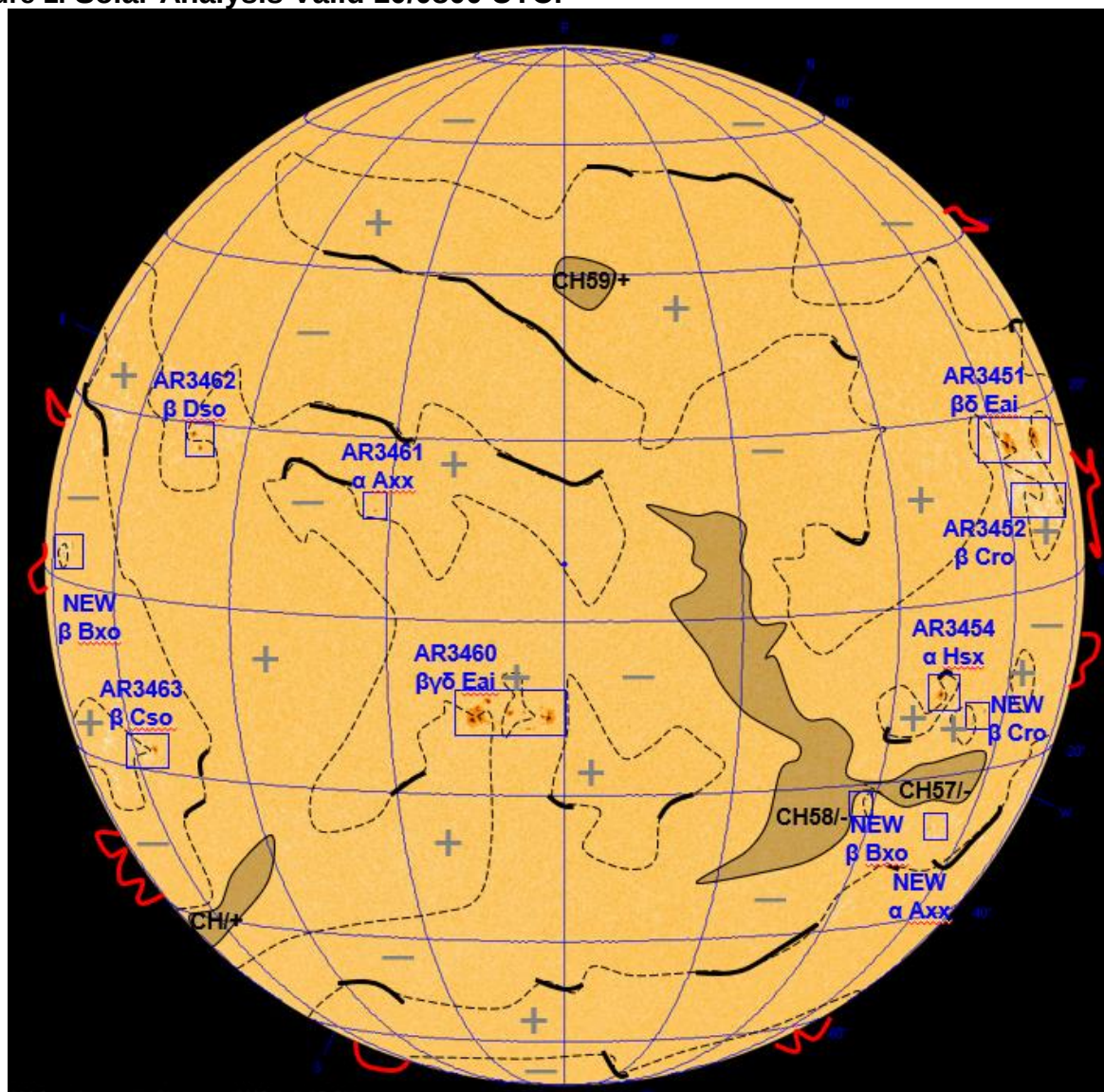
Solar Wind / Geomagnetic Activity: There is one Earth-directed CME which is anticipated to arrive either late Day 2 (11 Oct) or early Day 3 (12 Oct). Current slow wind is expected to transition into a weak stream of fast winds from CH57/- during Day 1 (10 Oct), followed by more pronounced HSS of CH58/- later Day 1 or Day 2. This likely bringing peak winds of around 500-

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600 km/s. Quiet (Kp 0-2) geomagnetic activity will increase to Unsettled to Active (Kp 3-4) at times of Days 1-3 (10-12 Oct) with the onset of the fast winds, and more probably with the CME arrival. There is a slight chance of a G1/Minor Geomagnetic Storm (Kp 5) Days 1-2 with the fast wind enhancements, and a chance of G1-G2 Minor/Moderate Geomagnetic Storm (Kp 5-6) intervals Day 2-3 (11-12 Oct) with the CME arrival.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is most likely to remain at background levels, with a slight chance of enhancements to R1/Minor Solar Radiation Storm levels if any notable flares from AR3451 or AR3460 occur. High energy electron flux (greater than 2MeV) is forecast to remain largely at background to moderate levels, dropping out with any fast wind or CME arrivals before potentially increasing Day 4 (13 Oct). Electron fluence is expected to remain below the Active (1e8 integrated pfu) threshold.

Figure 1. Solar Analysis Valid 10/0800 UTC.



Key: Filament ____, Prominence ____, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α - β - $\beta\gamma$ - $\beta\gamma\delta$ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

A CME associated with the C6.6 flare of AR3460 that left the Sun on 08/0339 UTC, is forecast to arrive at Earth late Day 2 (11 Oct), or more likely early Day 3 (12 Oct). No further Earth-directed CMEs have been observed.

Slow wind conditions initially, before Earth is likely move into a fast wind from CH57/- Day 1 (10 Oct) with a further transition later Day 1 or early Day 2 (10-11 Oct) into the broader high speed stream (HSS) from CH58/-, peaking at elevated levels of 500-600km/s, as supported by MOSWOC Enlil. SWPM supports the increase to a lesser extent, but with CH58/- more pronounced on this rotation compared to last, the strength of winds is likely to be under forecast in this model. Winds are anticipated to gradually easing towards background Day 4 (13 Oct).

Since around 10/1030 UTC STEREO-A has been showing signs of connection to a negative (towards the Sun) stream of fast winds, although no associated uptick in wind speeds has been observed.

Quiet geomagnetic activity will remain largely Quiet to Unsettled (Kp 0-3) on Day 1 (10 Oct), with a chance of Active (Kp 4) intervals later Day 1 or possibly early Day 2 (11 Oct) following the arrival of any CIR (co-rotating interactivity region) ahead of fast wind enhancements. Negative coronal holes are less likely to give strong connections near the September equinox (Russell-McPherron effect) however there is still a slight chance of a G1/Minor Geomagnetic Storm (Kp 5) interval. Later Day 2 or early Day 3 (12 Oct), activity will may become more Unsettled to Active (Kp 3-4) with a chance of G1-G2 Minor/Moderate Geomagnetic Storm (Kp 5-6) intervals due to any CME arrival coinciding with the HSS. Activity easing to mainly Quiet (Kp 0-2) by Day 4 (13 Oct).

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	20	30	30	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
08/1435	Partial	AR3460	SE	460 km/s	Late 11 / Early 12 Oct	Arrival and effects dependent on CH fast winds.

Figure 2: MOSWOC Enlil showing connection to coronal hole HSSs and CME arrival on 12 Oct. Onset of fast winds considered too quick in latest Enlil runs.

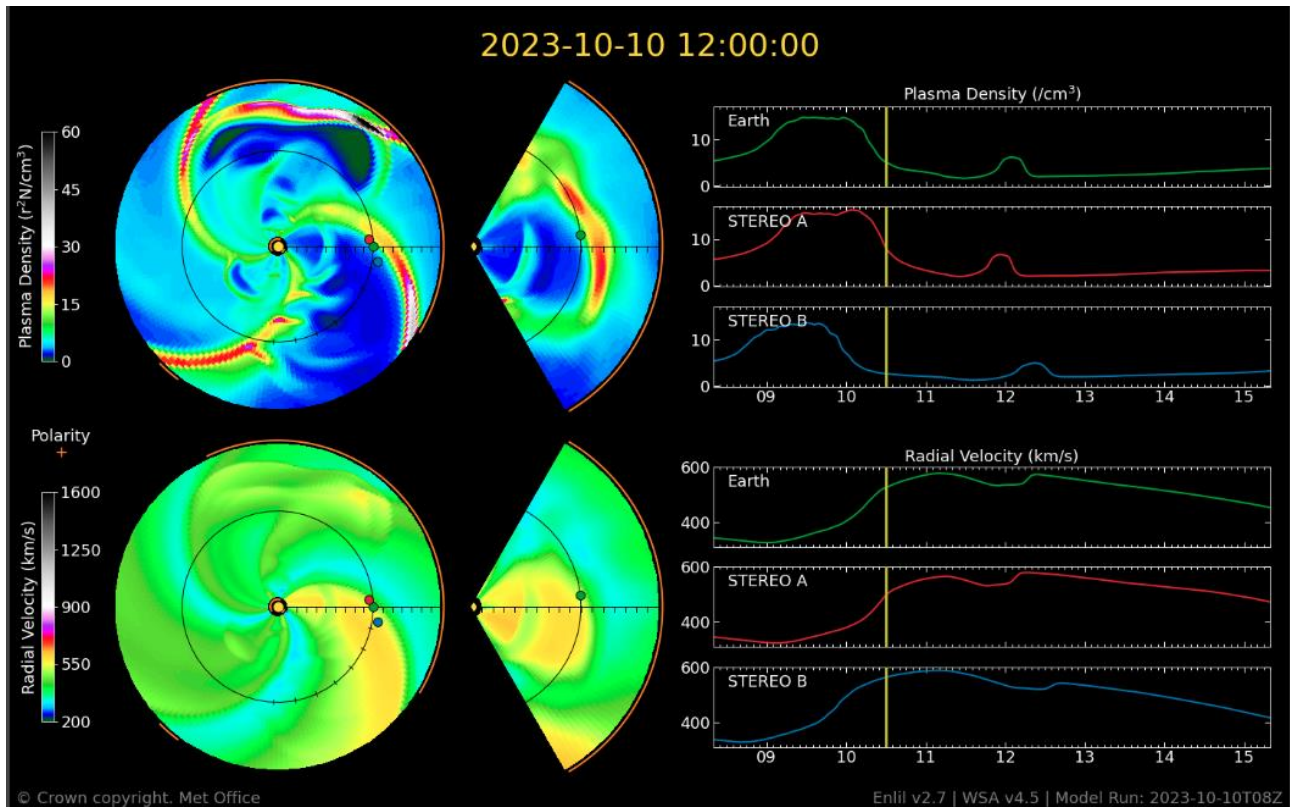


Figure 3: SDO/AIA 211 Imagery showing persistence and change in coronal holes between rotations.

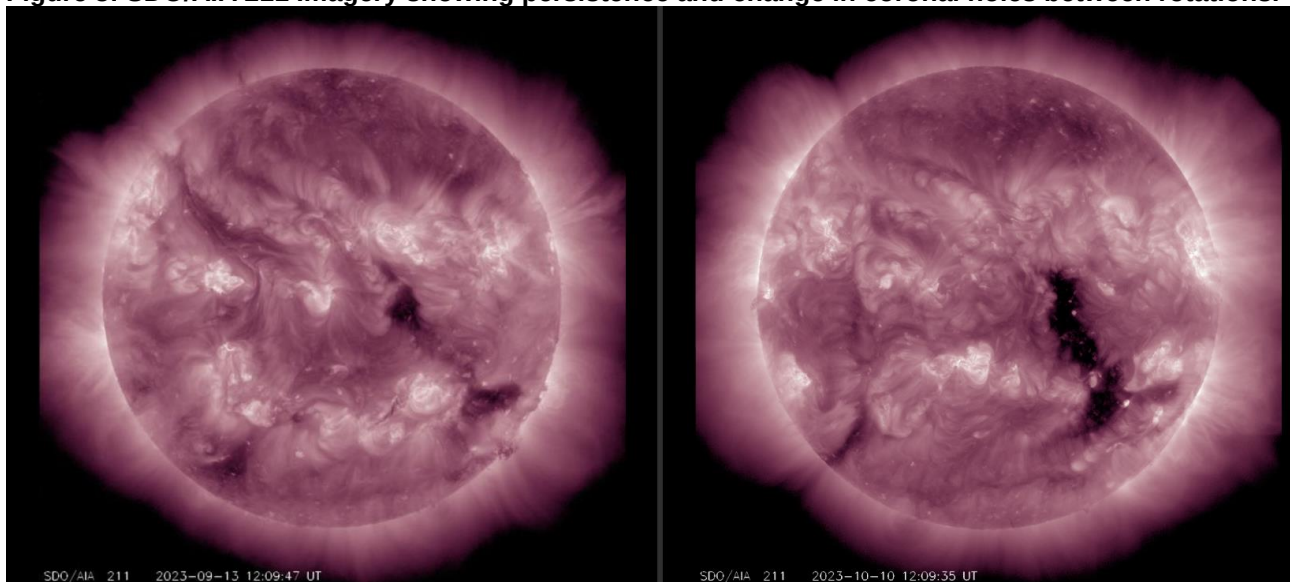
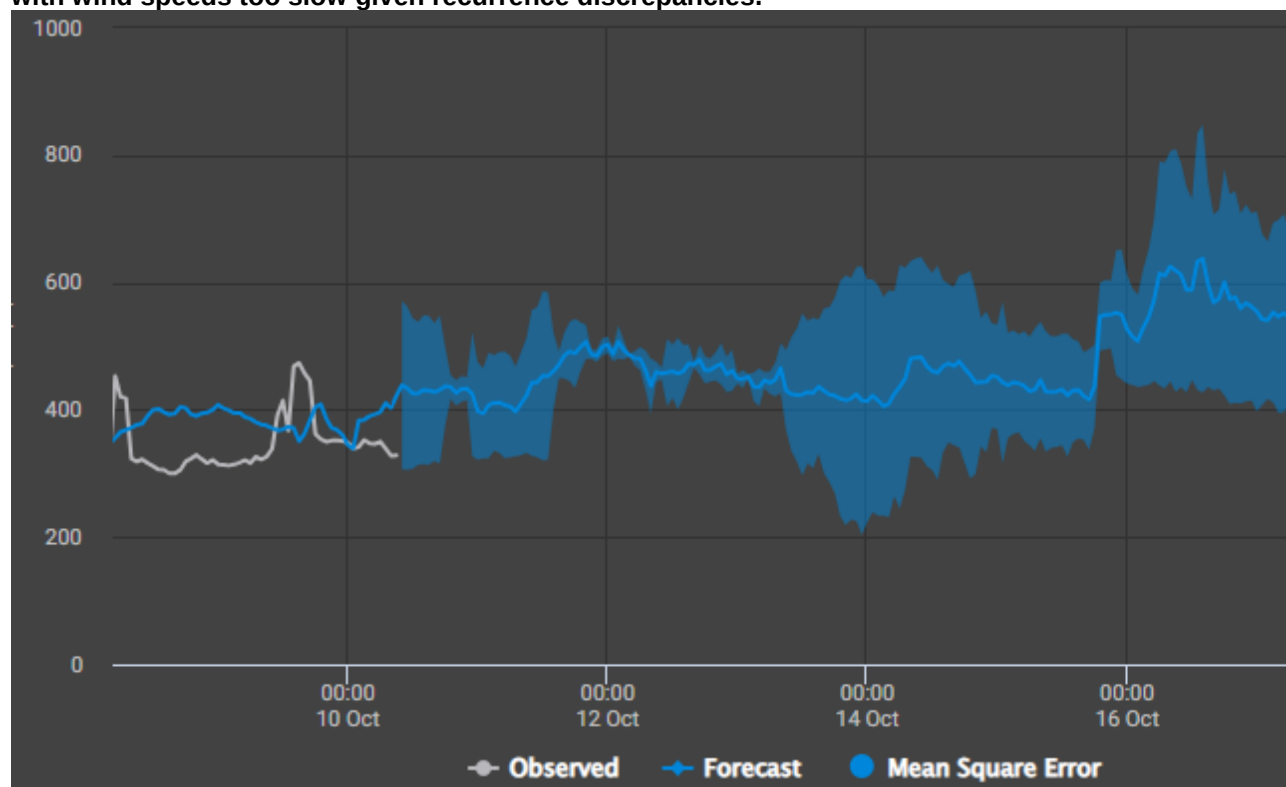


Figure 4: MOSWOC SWPM wind forecast. Considered to be giving reasonable steer for timings, but with wind speeds too slow given recurrence discrepancies.



Radio Blackouts - X-Ray Flares:

Solar Activity is forecast to be Low to Moderate with an ongoing risk of isolated M-class flares. The probability of M-flares is highest Days 1-3 (10-12 Oct) from either AR3451 or AR3460. The risk is then expected to diminish by Day 4 (13 Oct) as AR3451 rotates beyond the western limb. There is a slight chance of activity increasing to High due to a very isolated X-class flare, from either AR3451 or AR3460.

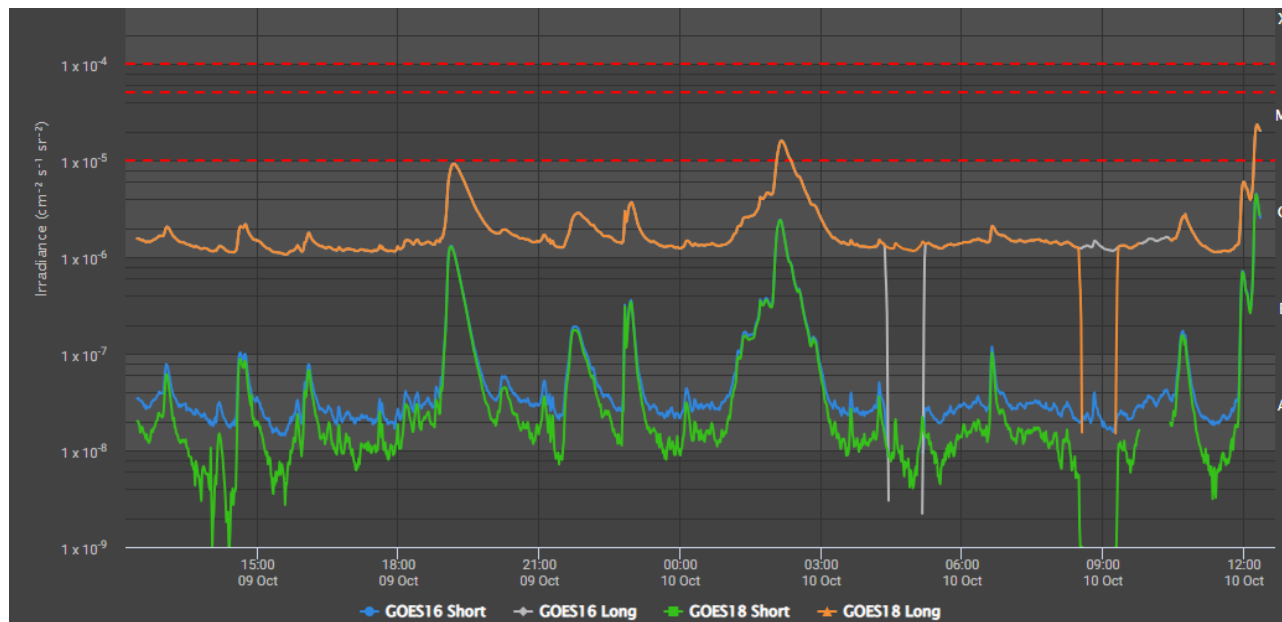
AR3451 (Eai/Beta-Delta) remains the largest and most active region on the disc with the delta spot on its main trailer region maintained. This region is connected to the weakened AR3452 (Cro/Beta) via plage. AR3460 (Eai/Beta-Gamma-Delta) maintains a relatively complex structure with a delta spot on its main trailing portion, and with some ongoing proliferation and fading of intermediate spots. This delta spot brings an increased risk of flaring, with a slight chance of X-class flares. The other spots on the disc are all comparatively smaller and simpler, and largely stable or decaying. Although several small and weak regions have recently emerged and one region in the northeast has developed penumbra.

Far-side seismic analysis and STEREO imagery suggests the potential for regions to rotate onto the disc from over the northeast limb Day 1-2, with a further region arriving Day 4.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	50	50	40

Very Active	R3 to R5 X Class	No	10	10	5	5
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Figure 5: GOES16 and GOES18 X-Ray trace. Note latest M2.3 since forecast issued.



Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is most likely to persist at background levels. AR3451 maintains its small delta spot on the trailing portion, and given its location on the northwest disc, brings an increased potential for proton flux to rise should any notable flares occur from this region. AR3460, in the centre disc, also contains a delta spot on its trailing portion. As this region rotates across the western disc, it will contribute towards the probability of proton events, with the slight chance of S1/Minor Solar Radiation Storms being maintained throughout the period.

Radiation Storms	Level (cm ⁻² sr ⁻¹ s ⁻¹)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	10	10	10	10
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = cm ⁻² sr ⁻¹ s ⁻¹)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) as observed by GOES16 has peaked at moderate levels at the diurnal maximum in recent days, but is expected to continue at mainly background levels. Any fast wind arrival from CH57/- or CH58/- may act to initially suppress observed values, alongside the potential CME arrival late Day 2 or Day 3 (11-12 Oct) but will see an increase in electron flux through the Van Allen Belts at lower orbits. This may lead to the observed flux at

GEO increasing as solar wind pressure eases, bringing a chance of Moderate levels, perhaps peaking at High on Day 4 (13 Oct).

Electron fluence is forecast to be well below the Active ($1\text{e}8$ integrated pfu) level throughout, however, albeit with an increasing trend from late Day 3 or Day 4 (12-13 Oct). MOSWOC REFM output is currently considered to be giving good guidance.

GEO Electron Environment	Level ($\text{cm}^{-2}\text{sr}^{-1}\text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2\text{ MeV}$ $\geq 1\text{x}10^8$	No	1	1	5	20
Very Active	$\geq 2\text{ MeV}$ $\geq 1\text{x}10^9$	No	1	1	1	1